

## Additional Miocene Anurans from Florida

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THE exceptionally large anuran fauna of the early Miocene beds of the Thomas Farm of Gilchrist County, Florida has been reported on by Tihen (1951), Auffenberg (1956), Holman (1961), and most recently by Holman (1965). In this last paper the new material of leptodactylid, ranid, and brevicipitid anurans was discussed, but the pelobatid, bufonid, and hylid frogs were not covered, mainly because of the lack of recent comparative material. Since that time more comparative material, as well as some new fossil material has become available. Thus, the present and final report details the pelobatid, bufonid, and hylid frogs (as well as new material of other anuran groups), and summarizes the knowledge of the early Miocene anurans of the Thomas Farm of Florida.

Anuran skeletons at Michigan State University and material borrowed or received as gifts from persons in the acknowledgments section have been used as comparative material. The following abbreviations are used: M.C.Z.—Museum of Comparative Zoology; U.F.—University of Florida; F.G.S.—Florida Geological Survey. Measurements are in millimeters.

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### FAMILY PELOBATIDAE

Pelobatids are known from the early Oligocene to the recent of North America. Zweifel (1956) and Tihen (1962) provide good accounts of the pre-Pleistocene forms.

*Scaphiopus* cf. *Scaphiopus holbrooki* (Harlan)

Previously, Auffenberg (1956) reported on four fragmentary ilia (U.F. 9896), one maxilla (U.F. 9897), three fragmentary frontoparietals (U.F. 9898), and one presacral vertebra (U.F. 9899) from the Thomas Farm of Florida.

*New material.* Two left and six right ilia (two left and four right F.G.S. V- 6063, and two right M.C.Z. 3445); one fragmentary sacrococcyx (M.C.Z. 3446), two left and three right maxillary fragments (F.G.S. V- 6084), and two skull fragments (F.G.S. V- 6085).

*Remarks.* Auffenberg discussed ilial characters of fossil and recent *Scaphiopus*. He reports that the subgenus *Scaphiopus* may be separated from the subgenus *Spea* on the basis that in the former group the dorsal prominence is either slightly developed or absent, and that when it is present it is a small rounded protuberance that is directed dorsolaterally and lies about halfway between the base and the end of the acetabular expansion. Auffenberg states that in the latter group this prominence is usually ridge-like, directed more dorsally, and that it contributes to the height and to the length of the dorsal portion of the acetabular expansion.

In the present study these characters were re-examined in the light of additional fossil and recent material. The prominence that Auffenberg refers to is for the tendinous origin of the vastus externus head of the M. triceps femoris as determined by the dissection of a recent *Scaphiopus h. holbrooki* from Putnam County, Florida. A prominence for the fleshy origin of this muscle occurs in *Rana pipiens* and in *Leptodactylus melanonotus* (Holman, 1965, p. 71, fig. 1, and p. 74, fig. 2). In these species the prominence is flatter and more extensive than in *Scaphiopus h. holbrooki*. The following recent pelobatid skeletons were studied by me. *Scaphiopus* (*Scaphiopus*) *h. holbrooki* (15), *S.* (*Scaphiopus*) *couchi* (5), *S.* (*Spea*) *bombifrons* (15), *S.* (*Spea*) *h. hammondi* (2), and *S.* (*Spea*) *h. multiplicatus* (3). Based on this material, most specimens of *Spea* and *Scaphiopus* may be distinguished from one another on the basis of their ilial prominences, but there is some overlap in a few large specimens of *Scaphiopus h. holbrooki* which have the ilial prominences as well developed as

in *Spea*. Nevertheless, if ilia of the same size are compared between the two subgenera the prominence is usually more developed in *Spea* than in *Scaphiopus*. Moreover, *Scaphiopus holbrooki* has this prominence more highly developed than in *S. couchi*. The eight new ilia (Fig. 1a) as well as Auffenberg's four fragmentary ilia resemble *Scaphiopus holbrooki* in this character.

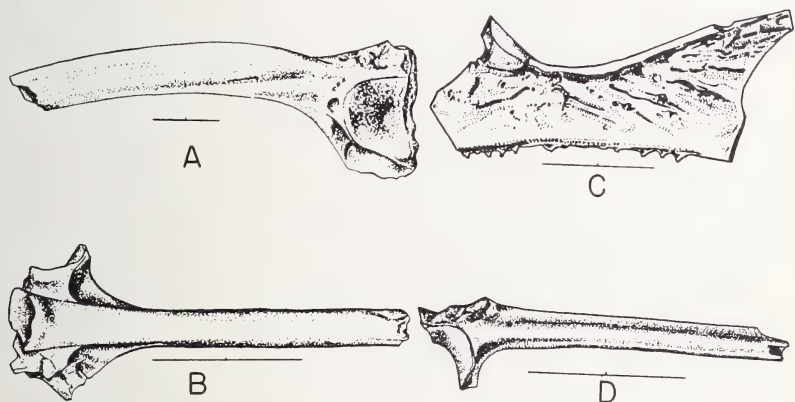


Fig. 1. A, left ilium of *Scaphiopus* cf. *S. holbrooki* F.G.S. V- 6063; B, sacrocoecyx of *Scaphiopus* cf. *S. holbrooki* M.C.Z. 3446; C, maxillary fragment of *Scaphiopus* cf. *S. holbrooki* F.G.S. V- 6084; D, right ilium of *Eleutherodactylus* sp. indet. F.G.S. V- 6086. Each line equals two millimeters.

The greatest height of the acetabulum of the eight measurable Thomas Farm *Scaphiopus* ilia (including Auffenberg's specimens) ranges from 1.8 to 3.1 with a mean of 2.41, thus the spadefoots were rather small. A recent adult male *Scaphiopus couchi* from San Luis Potosi, Mexico with a snout-vent length of 63 has a greatest height of the acetabulum of 4.0.

Fortunately, a pelobatid sacrocoecyx (Fig. 1b) is among the new material from the Thomas Farm. Tihen (1960) has summarized the works of Taylor (1942), Chrapliwy (1956) and Zweifel (1956), and has added his own comments on the osteological variability of the pelobatid sacrocoecyx. He indicates that although some variation exists, there are recognizable subgeneric and in some cases specific differences in the sacrocoecyx of the genus *Scaphiopus*. The Thomas Farm fossil is similar to *Scaphiopus holbrooki* in having the bony webbing between the sacral dia-

pophyses and coccygeal shaft limited in extent and regular in outline, and in having an ovaloid sacral cotyle. In material available to me, *Scaphiopus holbrooki* is readily separable from *S. couchi* in that it has the bony webbing between the sacral diapophyses and coccygeal shaft much more limited in extent than in *S. couchi*. The fossil clearly resembles *S. holbrooki* in this character.

The maxillae of *Scaphiopus* and *Spea* are quite distinct from one another. In *Scaphiopus* the maxilla in lateral view, is sculptured, flat or slightly to moderately concave, and the dorsal border of the bone is partly formed by a smooth, somewhat laterally produced shelf. In *Spea* the maxilla, in lateral view, is smooth, moderately to strongly convex, and the dorsal shelf is absent. The five new maxillae (Fig. 1c) are definitely referable to the subgenus *Scaphiopus* on the basis of these characters. Moreover, in available material, *S. holbrooki* differs from *S. couchi* in that in *S. couchi* the anterior part of the shelf that forms part of the dorsal border of the bone is interrupted by a sculptured portion anteriorly, whereas this portion of the bone is smooth in *S. holbrooki*. The fossils resemble *S. holbrooki* in this character. Thus, I would follow Auffenberg in designating all of the Thomas Farm pelobatid material as *Scaphiopus* cf. *S. holbrooki*.

#### FAMILY LEPTODACTYLIDAE

Leptodactylids are known from early Miocene and from Pleistocene deposits in North America (Holman, 1965). But leptodactylids may have been present in North America as early as upper Cretaceous (Estes, 1965).

#### Genus *Eleutherodactylus* Dumeril and Bibron

Based on the rather limited number of leptodactylid skeletons available (add the following specimens to the list of specimens studied in Holman, 1965, p. 69: *Eleutherodactylus podociferus* 2, *Leptodactylus bolivianus* 1, *Odontophrynus americanus* 1, *Pleurodema brachyops* 3, and *Syrrhophus campi* 1) the ilium of *Eleutherodactylus* may be separated from *Ceratophrys*, *Odontophrynus*, and *Pleurodema* in that the prominence for the origin of the

vastus externus head of the *M. triceps femoris* is moderately produced laterally rather than being a highly produced dorsal spike as in the latter three genera. *Eleutherodactylus* may be distinguished from *Leptodactylus* in that this prominence is less extensive, more knob-like, and usually less strongly bevelled. *Eleutherodactylus* usually has a better developed dorsal ilial crest than in *Syrrhophus* and *Tomodactylus*. Moreover, *Eleutherodactylus* has the prominence for the vastus externus head of the *M. triceps femoris* making a more oblique angle (posteroventral) to the shaft than in *Syrrhophus* in which this prominence is more nearly parallel to the long axis of the shaft. The following fossil represents the first record of the genus previous to the Pleistocene.

*Eleutherodactylus* sp. indet.

*Material.* Right ilium F.G.S. V- 6086 (Fig. 1d). Collected by Pierce Brodkorb. The fossil represents a small *Eleutherodactylus* that is of about the same size of recent *E. ricordi*. The little fossil is very similar to the ilia of several small Caribbean species of *Eleutherodactylus*, but because of the large number of described species of this genus and because of my lack of skeletal material of these forms I have not made a specific assignment for the fossil.

FAMILY BUFONIDAE

Bufonids are known from the early Miocene to the recent of North America. Tihen (1962) summarizes the occurrence of the known fossil New World bufonids.

*Bufo praeivus* Tihen

*Bufo praeivus* was described from the Thomas Farm by Tihen (1951) on the basis of a right ilium (M.C.Z. 1991). In addition, he referred the following material to this species. Eight ilia (M.C.Z. 1992); two tibio-fibulae (M.C.Z. 2000); five humeri (M.C.Z. 2002); three urostyles (M.C.Z. 1995); one femur (M.C.Z. 2005) and four vertebrae (M.C.Z. 1996). Auffenberg (1956) discussed *B. praeivus* and reported on a few additional elements.

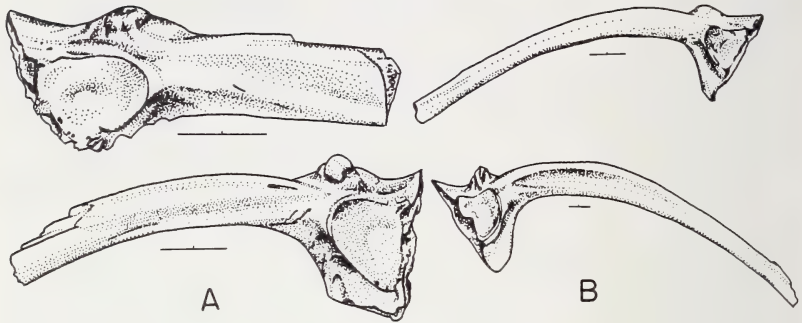


Fig. 2. A. top, right ilium of *Bufo praeivus*, bottom, left ilium of *Bufo praeivus*: B. top, left ilium of *Bufo terrestris*, bottom, right ilium of *Bufo terrestris*. Each line equals two millimeters.

Finally, Tihen (1962) thoroughly reviewed *B. praeivus* in the light of his intensive study of the osteology of recent and fossil *Bufo*. Tihen placed the affinities of *B. praeivus* with the *B. valliceps* group and suggests that it belongs with the Caribbean section of this group.

*New material.* Because of the hundreds of new bones available it was decided to study the large number of new ilia in an attempt to ascertain if indeed a single species of *Bufo* is represented by the Thomas Farm bufonid material as previously suggested by Tihen. This new material includes 175 left and 216 right ilia (135 left and 164 right F.G.S. V- 6087, 32 left and 49 right U.F. 10207, and three left and three right M.C.Z. 3447). In addition, hundreds of postcranial bones and fragments probably belong to this species.

*Remarks.* The series of 391 Thomas Farm *Bufo* ilia was compared with series of several recent *Bufo* species in an attempt to ascertain whether or not a single species of fossil was represented. I feel that Tihen was correct in assigning the Thomas Farm bufonid material to a single species. But the ilial prominence is more variable in shape than he indicated. Tihen (1962) states that this prominence is quite low, having a consistent height of about 20 per cent of the length of its base. Actually, although many individuals have a prominence with a height of about 15 to 20 per cent of the length of its base, some forms, usually those of larger size, have a much higher prominence (Fig. 2a). The

same variation in the shape of the ilial prominence obtain in recent *Bufo terrestris* (Fig. 2b).

#### FAMILY HYLIDAE

North American hylid fossils have previously been reported from the lower Miocene of Colorado (Chantell, 1965), Florida (Auffenberg, 1956 and Holman, 1961); from beds that are transitional between the uppermost Miocene and lowermost Pliocene in Nebraska (Chantell, 1964 and 1966); from upper Pliocene deposits in Kansas (Tihen, 1960 and Chantell, 1966); and from numerous Pliocene deposits. Estes (1964) indicates that there are "suggestions" that hylids may have been present in the upper Cretaceous of the Lance formation of Wyoming. Remarks on the structure of recent hylid skeletons in the following sections are based on the following comparative material: *Acris crepitans* (15), *A. gryllus* (6), *Anothea coronata* (2), *Diaglena reticulata* (2), *Gastrotheca marsupiata* (1), *Hyla arenicolor* (7), *H. californiae* (2), *H. cinerea* (4), *H. crucifer* (3), *H. ebraccata* (1), *H. elaeochroa* (5), *H. eximia* (2), *H. femoralis* (2), *H. gratiosa* (3), *H. miotympanum* (5), *H. phaeocrypta* (2), *H. regilla* (6), *H. septentrionalis* (1), *H. squirella* (10), *H. versicolor* (10), *H. wrigh-torium* (1), *Limnaeodius ocularis* (3), *Pseudacris nigrita* (8), *P. ornata* (1), *P. streckeri* (14), *P. triseriata* (10), *Phrynohyas spilomma* (2), *Phyllomedusa dacnicolor* (3), *Pternohyla fodiens* (3), *Smilisca baudini* (9), and *S. phaeota* (1). The terminology used by Chantell (1965, fig. 1) to describe features of the hylid ilium is used here. As has been pointed out by Chantell, the ilium is probably the best element to use to ascertain the relationships of fossil hylids. In the study of the above material I find that in some cases genera are quite satisfactorily separated from one another on the basis of ilial characters, especially when these genera consist of only a few or of a single species. Thus, *Acris* and *Anothea* may be quite easily defined on the basis of the ilium. But in the large genus *Hyla* the species are so variable that *Hyla* cannot be satisfactorily separated from *Diaglena*, *Phrynohyas*, *Pternohyla*, and *Smilisca*. Nevertheless, in many cases identifications can be made at the specific level in these groups.

I would like to make a few comments at this point on the four

*Hyla* "groups" of Lynch (1965). On the basis of material I have studied the *Hyla versicolor* group (*H. versicolor*, *H. phaeocrypta*, *H. gratiosa*, and *H. andersoni*) and the *Hyla cinerea* group (*H. cinerea*, *H. squirella*, and *H. femoralis*) are not distinct from one another. The *H. versicolor* group is defined as having a spine-like prominence, whereas the *H. cinerea* group supposedly has an oval-shaped prominence. I find only a few individuals of species of the versicolor group with spine-like prominences, indeed, most of them have ovaloid prominences. Moreover, quite a few smaller individuals in the *cinerea* group have round prominences.

### Genus *Acris* Dumeril and Bibron

Several workers (Chantell, 1964 and 1965, Holman, 1962 and 1964, and Lynch, 1962 and 1966) have pointed out characters that are diagnostic for the ilia of the genus *Acris*. These characters include the anterior position of the dorsal protuberance; the shape and narrowness of the ventral acetabular expansion, and the presence of a thin ridge along the top of the ilial shaft.

*Acris* sp. has previously been reported from the lower Miocene of the Pawnee Creek formation of Colorado (Chantell, 1965), and *Acris* cf. *A. crepitans* has been reported from the Miocene-Pliocene boundary of the Valentine formation of Nebraska (Chantell, 1964). The genus has been reported from numerous Pleistocene localities. New material from the Thomas Farm contains the ilia of a distinctive new species of *Acris*.

### *Acris barbouri* sp. nov.

*Holotype*. Right ilium U.F. 10208 (Fig. 3a). From Hawthorne formation, lower Miocene, Arikareean; Thomas Farm, Gilchrist County, Florida. Collected by Clayton E. Ray.

*Paratype*. Right ilium (F.G.S. V- 6088). From the same locality as the holotype. Collected by Pierce Brodkorb.

*Diagnosis*. A Miocene *Acris* that is readily distinguished from the recent species *Acris crepitans* Baird and *Acris gryllus* Le Conte in that its dorsal protuberance is relatively smooth and has its long axis about parallel to the long axis of the shaft, and in that its dorsal prominence is relatively short. The recent species



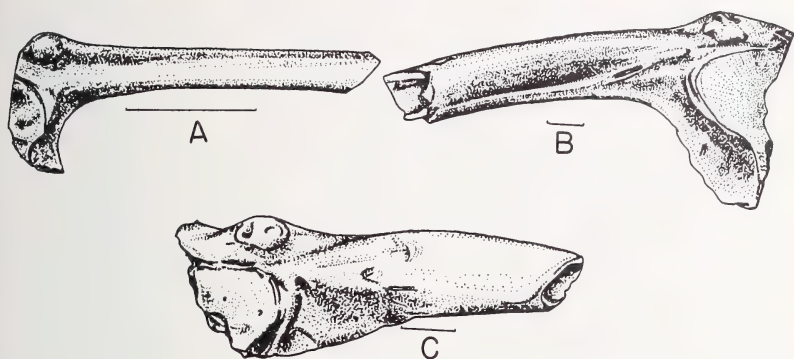


Fig. 3. A, holotype right ilium of *Acris barbouri* sp. nov.; B, holotype left ilium of *Hyla miofloridana* sp. nov.; C, right ilium of *Hyla* sp. indet. Each line equals one millimeter.

have the dorsal protuberance roughened or deeply notched, and with its long axis posteroventrally oblique to the long axis of the shaft. The dorsal prominence is longer in the recent species.

*Etymology.* The species is named in honor of the late Dr. Thomas Barbour in recognition of his successful efforts in securing the Thomas Farm as a study area.

*Description of holotype.* The dorsal acetabular expansion is broken just posterior to the dorsal protuberance. The dorsal prominence is not highly distinct and is shorter than in recent species of *Acris* studied. The dorsal protuberance is anterior in position, having its posterior border even with the anterior border of the acetabular fossa. The dorsal protuberance is ovaloid in shape, smooth, and has its long axis about parallel to the long axis of the shaft. The acetabular fossa has its posterior portion broken. It is moderately excavated and has its lower border well extruded. The tip of the ventral acetabular expansion is broken. The anterior border of the ventral acetabular expansion makes an angle of about 90 degrees with the shaft. The ventral acetabular expansion is quite narrow. The ilial shaft is compressed and has a moderately excavated area on its lateral surface just anterior to the dorsal protuberance.

*Variation in the paratype.* The paratype is from a somewhat larger individual and shows some slight differences that may be

attributed to individual variation. The dorsal protuberance is a little rougher and the angle between the ilial shaft and the anterior border of the ventral acetabular expansion is slightly greater than in the holotype. The ilial shaft of the paratype is more complete and shows the beginning of the thin dorsal ridge that is found in recent *Acris* species.

*Remarks.* The Thomas Farm ilia are easily separable from recent *Acris* species. This is interesting in that the recent species are almost impossible to separate from one another and in that Chantell states that in his *Acris* sp. from the lower Miocene of Colorado "The differences between the fossil ilium and the modern ilia of both species appear so slight that I believe the specimen is simply a lower Miocene representative of population lines leading to modern *A. crepitans* or *A. gryllus*". If this is indeed the case, then two species of *Acris* were present in the lower Miocene of North America.

#### Genus *Proacris* Holman

This extinct genus was described by Holman (1961) and remains the most bizarre element of the Thomas Farm anuran fauna and the only currently recognized extinct anuran genus of the late Tertiary in North America. Unfortunately, although much additional anuran material has accumulated from the Thomas Farm, none of it is assignable to *Proacris*. The ilium of *Proacris* (F.G.S. V- 5950) is easily separable from all of the hylid species I have seen in having its acetabular cup much enlarged and almost entirely encroaching the much reduced ventral acetabular expansion, and in having a pronounced ridge just posterior (not anterior as it states in Holman, *op. cit.*) to the dorsal protuberance.

#### *Proacris mintoni* Holman

*Remarks.* Holman suggested that *Proacris* might either be ancestral to *Acris* (the fossil resembles *Acris* somewhat in the size of its ventral acetabular expansion and in the anterior position of its dorsal protuberance) or that possibly *Proacris* represented an archaic hylid line that is not particularly close to the ancestry of living forms. With the occurrence of *Acris barbouri* in the same deposit the latter thesis becomes acceptable. Possibly, both

*Acris* and *Proacris* have a common ancestor that lived quite early in the Tertiary.

### Genus *Hyla* Laurenti

North American fossils of the genus *Hyla* have been reported from the lower Miocene of the Thomas Farm of Florida (Auffenberg, 1956); from beds that are transitional between uppermost Miocene and lowermost Pliocene times in Nebraska (Chantell, 1964) and from numerous Pleistocene deposits.

The ilium of *Hyla* differs from *Acris* in that the angle between the anterior border of the ventral acetabular expansion and the ilial shaft is always greater than 90 degrees, where in *Acris* it is about 90 degrees. In most *Hyla* the dorsal protuberance is more posterior with respect to the anterior edge of the acetabulum than in *Acris* (Chantell, 1964, Holman, 1964, Lynch, 1966). In most *Hyla* the anterior edge of the dorsal protuberance lies about even with or posterior to the anterior edge of the acetabulum, whereas in *Acris* at least half of the length of the dorsal protuberance projects anterior to the anterior edge of the acetabulum. *Hyla californiae*, *H. crucifer*, *H. eximia*, and two of six *H. regilla* are similar to *Acris* in this character. In *Hyla* the ventral acetabular expansion is much wider than in *Acris*. Finally, with the exception of one of seven *Hyla arenicolor* and two of three *H. crucifer*, the thin dorsal ridge that is present on the ilial shaft of *Acris* (Lynch, 1962) is absent in *Hyla*.

*Hyla* differs from *Anothea* in that the dorsal protuberance of the ilium, although quite variable in shape, is always better developed. In *Anothea* the dorsal protuberance is obsolete and quite irregular in shape. But in other ilial characters the two genera are quite similar.

The ilium of *Hyla* differs from *Gastrotheca* in that the angle between the anterior border of the ventral acetabular expansion and the ilial shaft is always more than 90 degrees in *Hyla* and is about 90 degrees in *Gastrotheca*. The ilia of these genera otherwise are similar.

*Hyla* may be separated from *Limnaeodus* in that the angle between the anterior border of the ventral acetabular expansion and the ilial shaft is always more than 90 degrees in *Hyla*, whereas in *Limnaeodus* this angle is about 90 degrees. Moreover, *Hyla*

usually lacks the thin dorsal ridge that occurs on the ilial shaft of *Limnaeodus*.

In *Hyla* the dorsal protuberance is rounded, ovaloid, triangular, or very occasionally irregular in shape, and is produced dorso-laterally, whereas in *Phyllomedusa* the dorsal protuberance is spike-shaped and dorsally produced, much as in some species of *Bufo*. Moreover, in *Hyla* the ventral acetabular expansion is wider and has its ventral border much less broadly truncate than in *Phyllomedusa*.

*Hyla* and *Pseudacris* are quite similar in ilial structure, the most consistent difference between the two genera being the wider ventral acetabular expansion of *Hyla*.

I am unable to distinguish the ilia of *Hyla* from *Diaglena*, *Phrynohyas*, *Pternohyla*, and *Smilisca* on any single character. Thus, the identification of hyloid fossils of the above genera must be made at the specific level.

*Hyla miofloridana* sp. nov.

*Holotype*. Right ilium U.F. 10209 (Fig. 3b). From Hawthorne formation, lower Miocene, Arikareean; Thomas Farm, Gilchrist County, Florida. Collected by Clayton E. Ray.

*Diagnosis*. A moderately large *Hyla* showing similarities to Recent *Hyla cinerea* (Schneider), *H. gratiosa* Le Conte, and *H. versicolor* Le Conte, but differing rather strongly from these forms in having the dorsal protuberance less produced and less distinct from the ilial prominence, and in having a groove with a strong ventral border on the lateral face of the ilial shaft just anterior to the acetabulum.

*Description of holotype*. The tip of the dorsal acetabular expansion is broken and the part remaining has its broken surface worn rather smooth. The dorsal protuberance is ovaloid in shape, rather weakly produced, and it is not highly distinct from the dorsal prominence. The protuberance is slightly roughened in shape. The anterior edge of the dorsal protuberance lies even with the anterior edge of the acetabulum. The distance of the protuberance to the acetabular border is less than one-third the length of the protuberance. The acetabular fossa is only moderately excavated and its border is rather weak. The ventral

acetabular expansion is well developed and wide. The anterior edge of the ventral acetabular expansion makes an angle of much greater than 90 degrees with the ilial shaft. The extreme tip of the ventral acetabular expansion is broken. The ilial shaft is compressed and lacks a ridge or crest along its dorsal surface. Just anterior to the anterior edge of the ventral acetabular expansion, the shaft has a pronounced groove on its lateral face. This groove has a rather strong ventral border. Measurements: greatest height of shaft 1.8, height of acetabular fossa 2.8, length of dorsal protuberance 1.4.

*Remarks.* The fossil is most similar to recent *H. cinerea*, *H. versicolor*, and especially to *H. gratiosa*, but it shows differences that I believe indicate it is at least specifically distinct. The grooved lateral surface of the ilial shaft is a very strong character that I have found duplicated in only one other hylid, a single specimen of *H. septentrionalis*. But *H. septentrionalis* differs from the fossil in several characters as follow: the dorsal protuberance is triangular in shape and strongly produced laterally; the acetabular cup is more strongly excavated and has a stronger border; and finally, the anterior edge of the ventral acetabular expansion is more highly curved and makes a wider angle with the shaft.

*Hyla* sp. indet.

An ilium (F.G.S. V- 6089, Fig. 3c) may represent a second moderately large species, but unfortunately, the bone is too fragmentary for a specific identification. In fact, part of the fossil in the area of the ventral part of the acetabular region is so worn that many important features are obscured. A description of the fossil is as follows. There is no fossa posterior to the dorsal protuberance. The anterior edge of the dorsal protuberance lies slightly anterior to the anterior edge of the acetabular fossa. The dorsal protuberance is ovaloid and strongly produced laterally. The shaft is compressed and lacks either a dorsal ridge or a crest. There is no groove on the lateral face of the ilial shaft. The dorsal acetabular expansion, almost all of the ventral acetabular expansion, and about the posterior one-half of the acetabular fossa are broken.

*Hyla goini* Auffenberg

*Hyla goini* was described from the Thomas Farm by Auffenberg (1956) on the basis of a right ilium (M.C.Z. 2277) and three paratype ilia (U.F. 9900).

*New material.* Fourteen left and 20 right ilia (11 left and 14 right F.G.S. V- 6090, three left and five right U.F. 10210, and one right M.C.Z. 3448); four left and one right scapulae (three left F.G.S. V- 6091, and one left and one right M.C.Z. 3449) one radioulna (M.C.Z. 3450); and one coracoid (M.C.Z. 3451).

*Remarks.* In the light of the additional fossil material and much more comparative material it was decided to re-examine *Hyla goini*. On the basis of this re-study it appears that all of the small *Hyla* ilia of the Thomas Farm represent one variable species of *Hyla*, namely *Hyla goini*. The variation encountered in the 38 *Hyla goini* ilia is very similar to that one finds in a series of ilia of recent *Hyla squirella*, a small species that occurs in Florida today. Some of these variations appear to be ontogenetic. In small *Hyla goini* and *H. squirella* the dorsal protuberance tends to be small, round, and relatively far away from the dorsal border of the acetabulum (Fig. 4a and b). But in larger individuals of the fossil and of the recent species the protuberance is larger, ovaloid in shape, and relatively near the dorsal border of the acetabulum. Individual variation in *H. goini* and *H. squirella* includes such features as slight differences in the shape of the dorsal protuberance, small differences in the angle between the anterior border of the ventral acetabular expansion and the shaft, and slight differences in the width of the ventral acetabular expansion.

A redescription of *Hyla goini* in the light of the new ilia that are available is as follows. The dorsal acetabular expansion is pointed and moderately long. The dorsal protuberance is well-developed and is produced dorsolaterally. It ranges in shape from round in small individuals to ovaloid in larger forms. The anterior edge of the dorsal protuberance is usually even with the anterior edge of the acetabular border, but in some individuals it lies somewhat anterior to this border. The drawing of the holotype of *Hyla goini* in Auffenberg (1956, p. 9, fig. 3f) does not accurately show the appearance of the dorsal protuberance in this species. In the figure the dorsal prominence is produced

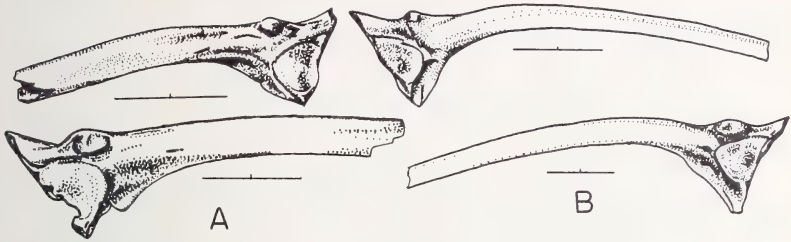


Fig. 4. A, top, left ilium of *Hyla goini*, bottom, right ilium of *Hyla goini*; B, top, right ilium of *Hyla squirella*, bottom, left ilium of *Hyla squirella*. Each line equals two millimeters.

above the dorsal protuberance. In the ilia of *Hyla goini* the protuberance is produced above the prominence. The distance of the dorsal protuberance from the acetabular border varies from that of a little under the length of the protuberance to about one-third the length of the protuberance. The ilial shaft is compressed and lacks a dorsal crest or ridge. Its lateral side is usually smooth, but some individuals have a rather indistinct lateral groove or depression. The anterior border of the ventral acetabular expansion always makes an angle of well over 90 degrees with the ilial shaft, but there is some variation in this angle. The ventral acetabular expansion ranges in width from about one-third as wide as the length of the acetabulum to about one-half as wide as the acetabulum. In the few specimens that have an almost complete ventral acetabular expansion, the tip appears to have been quite pointed.

*Hyla goini* is quite similar to recent *Hyla squirella* and *H. femoralis*. Of these two species, the fossil is closer to *H. squirella* than to *H. femoralis* on the basis of the shape of the dorsal protuberance which is never as elongate as in *H. goini* and *H. squirella*. In fact, I can find no consistent characters by which to separate *H. goini* from *H. squirella* on the basis of the ilium, and indeed, *H. goini* may well be directly ancestral to *H. squirella*. I can see no resemblance of *H. goini* to *Pseudacris* as suggested by Auffenberg (1956).

#### FAMILY RANIDAE

Ranid fossils are known from the early Miocene to the recent

of North America. Holman (1965) summarizes the occurrences of known ranid fossils in North America.

*Rana* cf. *Rana pipiens* Schreber

Two ilia (one left U.F. 10203 and one right M.C.Z. 1994) that Holman (1965) was unable to distinguish from recent *Rana pipiens* have previously been reported from the Thomas Farm.

*New material.* Three right ilia (F.G.S. V- 6092). These ilia are also indistinguishable from recent *Rana pipiens* and are thus tentatively assigned to this species.

CHECK LIST OF THOMAS FARM ANURAN

Extinct species are marked by an asterisk, extinct genera by two asterisks. Numbers refer to minimum number of individuals represented of each species)

Family Pelobatidae

*Scaphiopus* cf. *Scaphiopus holbrooki*, 6

Family Leptodactylidae

\**Leptodactylus abavus*, 4

?\**Eleutherodactylus* sp. indet., 1

Family Bufonidae

\**Bufo praeivus*, 216

Family Hylidae

\*\**Proacris mintoni*, 1

\**Acris barbouri*, 2

\**Hyla miofloridana*, 1

?\**Hyla* sp. indet., 1

\**Hyla goini*, 20

Family Ranidae

\**Rana miocenica*, 1

\**Rana bucella*, 1

*Rana* cf. *Rana pipiens*, 4

Family Brevicipitidae

*Gastrophryne* cf. *Gastrophryne carolinensis*, 1



## PALEOENVIRONMENT

Estes has supported the more or less widely accepted idea that the Thomas Farm deposits represent the filling of a sinkhole in a porous, eroded limestone terrain. Estes further points out that "This situation is most plausibly interpreted as a sinkhole with internal drainage (probably spring-fed, since connection with other drainage systems would be indicated by the presence of freshwater fishes) which, as a result of the available water, drew to it animals from diverse habitats.

The anuran fauna represents an assemblage that could have existed in the immediate vicinity of a spring-fed, sinkhole pond. It is difficult to suggest the exact nature of the pond, but it seems quite possible that it could have been a rather temporary one. With the possible exception of a few ranids, all of the Thomas Farm anurans should have been able to breed in such situations. It is interesting to note in this regard that 83 per cent of the minimum number of individual anurans in the Thomas Farm fauna (216 out of 259) belong to a single species of toad, *Bufo praeivius*. Toads of the genus *Bufo* typically breed in small ponds, often ones of a temporary nature. The lack of large "bullfrogs" of the genus *Rana* has been noted before (Holman, 1965). Possibly the absence of large ranid frogs is correlated with the fact that the pond was a temporary one, for most large *Rana* require a relatively long time for larval development.

## PHYLETIC RELATIONSHIPS

The most striking aspect of the Thomas Farm anuran fauna is that it is an essentially modern one. All of the anuran families that occur in Florida today are present and there are no extinct families. All of the genera that are indigenous to Florida today are present with the exception of *Pseudacris* and *Limnaeodius*, and only one genus (*Proacris*) is extinct. Two genera (*Eleutherodactylus* and *Leptodactylus*) that occur in the Thomas Farm fauna do not occur naturally in Florida at present, but are found in the western Gulf States and in the Caribbean region today.

Three species (*Scaphiopus* cf. *S. holbrooki*, *Rana* cf. *R. pipiens*, and *Gastrophryne* cf. *G. carolinensis*) are indistinguishable from

species living in the area today, and indeed may represent these species. Other species are possibly directly ancestral to species living today. These include *Leptodactylus abavus* which is similar to recent *L. melanonotus* and *Hyla goini* which is similar to recent *Hyla squirella*. Other forms (*Eleutherodactylus* sp., *Bufo praeivius*, and *Hyla miofloridana*) are of less certain specific relationships. *Eleutherodactylus* sp. is similar to several small species of the West Indian region. *Bufo praeivius* is similar to the Caribbean section of the *Bufo valliceps* species group of Tihen (1962). *Hyla miofloridana* shows similarities to *H. cinerea*, *H. gratiosa*, and *H. versicolor*. Finally, there are several quite distinct species that probably became extinct without replacement. These forms include *Acris barbouri*, *Rana miocenica*, and *Rana bucella*.

#### ZOOGEOGRAPHIC AFFINITIES

Because of the fragmentary and localized nature of the anuran fossil record it is difficult to make zoogeographical interpretations based on the Thomas Farm anuran fauna. Nevertheless, some of the fossil anuran taxa can be grouped in zoogeographic categories relative to the distribution of related living forms. Species of unknown geographic affinities such as the extinct species *Acris barbouri*, *Proacris mintoni*, *Rana miocenica*, and *Rana bucella*; and forms that are of very widespread occurrence today such as *Rana* cf. *R. pipiens* cannot be grouped zoogeographically. The other Thomas Farm anurans are grouped under the following tentative categories.

*West Indian*.—These include *Eleutherodactylus* sp. and *Bufo praeivius*. *Eleutherodactylus* sp. is similar in structure to several small Caribbean species of the genus. *Eleutherodactylus ricordi* occurs in Florida today, but it is said to have been introduced from the West Indies (Schmidt, 1953). *Bufo praeivius* is placed in the Caribbean section of the *Bufo valliceps* species group, and it is suggested that *B. praeivius* may have arrived in Florida from Cuba (Tihen, 1962). It is interesting to note that Estes (1963) identified *Leiocephalus*, a lizard with definite West Indian affinities, from the Thomas Farm. Estes suggests that this lizard represents a sweepstakes occurrence.

*Southeast Coastal Plain*.—The present day anuran fauna of

Florida is one that has largely been derived from the Southeast Coastal Plain of the United States. Thomas Farm anurans that have recent relatives that are typical of the Southeast Coastal Plain are *Scaphiopus* cf. *S. holbrooki*, *Hyla miofloridana*, *H. goini*, and *Gastrophryne* cf. *G. carolinensis*.

*Western Gulf States.*—The fossil *Leptodactylus abavus* is quite similar to recent *L. melanonotus* which today ranges from southern Sonora and San Luis Potosi southward along both Mexican coasts to Costa Rica (Smith and Taylor, 1948). The genus *Leptodactylus* is absent from Florida today, but species of this genus occur in southern Texas and in a few islands of the West Indies. Again, the possibility exists that the fossil *Leptodactylus* has Caribbean affinities, but at present, I feel that this possibility is a slight one.

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